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Natural regeneration in storm damaged woods – 1987 storm sites revisited

by
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SUMMARY: In 2002 a survey was carried out on 20 sites that had been damaged by the 1987 storm; the amount, size and species of naturally regenerating trees were assessed and comparisons made with an initial survey made in summer 1988. A total of 22 tree and shrub species was found and saplings of the most abundant species were generally well established being up to 11m tall and 7cm in diameter. The predominant species regenerating changed between observations. At many sites seedling oak and beech were replaced by sapling birch. The type and amount of vegetation varied between sites; it appeared to be related to soil type and to influence sapling density. The number of species present on sample plots varied between 0 and 8 with total sapling densities of up to 40,000 ha^{-1}. Successful regeneration of broadleaved trees (>1100 ha^{-1}) occurred on 75% of sites, but the dominant species was usually different to the original crop.

Introduction

The great storm of October 1987 had a dramatic effect on many woodlands in the south-east of England: approximately 3.9 million m^3 of timber was blown and 16,000ha of woodland was sufficiently badly damaged to need complete clearance (Grayson 1989). Effects appeared to be worst in intensively managed woods, with plantations of conifers and beech suffering badly. Beech was also badly affected in semi-natural woodlands. Considerable effort was put into tidying up the damage and carrying out operations to ensure that woodlands were restocked. This has been described by Whitbread (1991a) as the "clear up the mess and replant" approach and an analysis of data from the Woodland Grant Scheme database indicated that in the 5 years following the storm 90% of restocking in private woodlands was achieved by planting (Harmer, 2002). Contemporary publications also included some advice on natural regeneration as a method of restocking (Anon, 1988; Grayson, 1989), but at the time this was a largely untried procedure outside the experience of most woodland managers.

More than 20 studies were established in the immediate aftermath of the storm (Whitbread, 1994). Early results of some were published (Spencer and Feest, 1994; Kirby and Buckley, 1994; Whitbread, 1991b) and subsequently there have been several reports from longer-term observations (e.g. Mountford, 2002, 2004; Mountford and Peterken, 2000, 2001; Mountford and Ball 2004; Mountford and Groome 2004).

In Summer 1988, one year after the storm, the Forestry Commission's Research Division surveyed broadleaved natural regeneration at 45 wind-damaged sites. The results indicated that about 25% of sites with oak and beech seedlings, and all sites with ash seedlings, were 'adequately' stocked (i.e. more than 2000 seedlings ha^{-1}). Although the data implied that these sites would regenerate successfully, a note of caution was made suggesting that protection from browsing damage and planting of gaps would be necessary (Grayson, 1989). The following paper describes the results of a survey in which some of these sites were revisited 14 years after the initial study in order to see how well they had regenerated.

1988 Survey

In the summer of 1988 a survey was made to record the number and species of naturally regenerating trees in 275 plots; these were located at 45 sites in 15 locations in southern England. The plots were 4m in radius and centred at the base of a tree that may have been standing, leaning, uprooted or felled. On small patches of windblow the plots were centred around individual trees or stumps, but on large areas they were located randomly using co-ordinates on a temporary grid. Although a variety of site characteristics, such as stand composition, vegetation, depth of leaf-litter and ground disturbance, were also assessed, these were not satisfactorily recorded and could not be related to seedling numbers in either this or the later survey.

2002 Survey

During late autumn 2002 and early winter 2003 the sites were re-surveyed. However, it was not possible to revisit all of them, the reasons for which included: insufficient information on current ownership and failure to obtain permission to survey; renumbering of sub-compartments and the lack of old stockmaps; and poor initial grid references. A total of 20 sites were re-surveyed. Assessment plots were circular with a radius of 5.64m: a total of 67 were observed. The target number of plots to be assessed at each site varied in relation to its area: 1 plot for < 0.2ha; 3 plots for 0.21 ≤ 0.5ha; 5 plots for 0.51 ≤ 1ha; and 10 plots for sites >1ha. However, due to constraints of time, the target number for sites >1ha was not reached. The target number and location of plots was determined in the field after establishing the size, shape and distribution of the windblown area: on large areas the plots were spaced systematically by pacing along transects (Kerr et al, 2003); on small areas they were placed centrally.

Species	Sites 1988	Sites 2002	Plots 2002
Birch		15	40
Beech	**14**	**10**	**29**
Willow		9	23
Sycamore	**3**	**8**	**12**
Oak	**7**	**7**	**11**
Holly		6	11
Ash	**4**	**5**	**24**
Elder		4	4
Gorse		4	5
Hawthorn		4	7
Sweet chestnut	1	4	4
Dogwood		3	3
Hazel		3	8
Rowan	1	3	3
Field maple	1	2	3
Hornbeam		2	2
Scots pine		2	4
Alder		1	1
Buddleia		1	1
Guelder rose		1	1
Lime		1	1
Western red cedar		1	1

Species in bold are classed as timber species. The data are for the 20 sites that were visited in both surveys, a total of 133 plots were surveyed in 1988 and 67 in 2002.

Table 1. Number of sites and plots where regenerating tree and shrub species were recorded in 2002 and 1988.

The following data were recorded for each plot:

Site – Geographical or forest area and name of woodland.

Species of tree regeneration – These are referred to as timber species (i.e. ash, beech, oak and sycamore) and minor species (all other species). The numbers and heights of saplings (≥ 1.5m tall, in 50cm classes) and seedlings (> 0.3 < 1.5m tall, in 20cm classes) of each species were recorded. Sapling diameter was also assessed. The occasional tree planted post-windblow was ignored.

Ground flora – Vegetation on the site was classified into 5 types – bramble, bracken, grasses, herb and ferns, and shrubs (other than those listed in Table 1). The percentage cover of the two most abundant types, henceforth called the dominant and sub-dominant vegetation, was recorded on a 5 point scale (≤ 5%, 5-15%, 16-35%, 36-75%, 76-100%).

Data Presentation

The only data shown for the 1988 survey are those for sites re-visited during the 2002 survey. The information for the 1988 survey has been taken from the internal report produced which contains the only existing record of the data. The differences in the format and type of data collected at each survey, the difficulties in exact relocation of plots, and the inconsistencies of the data sets, negate detailed statistical comparison between the surveys. Statistical investigation of the data for the relationships between vegetation, soils and stocking were carried out on 2 x 2 contingency tables using Fisher's exact test.

Results

The plots were located in Hampshire, East Sussex and Kent. The soils varied; those at Queen Elizabeth Forest and Friston were thin calcareous soils overlaying chalk, those at Alice Holt and East Hampshire were seasonally water-logged clays, whilst other sites had well-drained, coarse loamy soils.

Tree Species Regenerating

In 2002 a total of 22 tree and shrub species were recorded in the plots (Table 1). Most were infrequent occurring on fewer than 5 sites, and fewer than 9 plots. Birch was the most frequent species, whilst beech was the most frequent timber species. Only 7 species were recorded in 1988 and most were timber species (Table 1). The apparent lack of species present in 1988 probably reflects not only the difficulty of finding small seedlings of species such as birch and willow during their first growing season, but also the interest in mainstream forestry species that prevailed at the time, which may have lead to the under-recording of minor species.

Site	Seedlings 1988	Saplings 2002			Seedlings 2002	
		Species	Height (m)	DBH (cm)	Species	Height (m)
Alice Holt						
Holt Pound	Oak	Birch	1.5	1	Oak	0.6
Abbotts Wood	Beech	Beech	5	3	Holly	1.2
Goose Green	Oak	Sycamore	2.5	4	Sycamore	*
East Hampshire						
Creech	Oak	Birch	6	7		
Queens Enclosure	Oak	Birch	3	4		
Queen Elizabeth Forest						
War Down	Beech	Beech	3	3	Alder	*
Head Down	Ash	Ash	3	1.5	Ash	*
Glass Brow	Ash	Ash	7	2.5	Ash	0.6
Holt Down	Ash	Ash	5	3	Ash	1
East Sussex						
Friston 1	None	Sycamore	6	4	Sycamore	1.4
Friston 2	None	Willow	7	8		
Friston 3	None	Beech	3	1		
Friston 4	Beech	Elder	2	4		
Wych Cross	None	Birch	10	5	Holly+	0.2
Legs Heath	Beech	Birch	8	5		
Kent						
King's Wood	Beech	Birch	8	6		
Toy's Hill	Beech	Birch	11	5	Holly	1.2
Seven Oaks	Oak	Birch	7	3		
Scotney Castle	None	Birch	9	7		
Knole Park	Beech	Birch	6	4		

None = no seedlings present. Height and DBH are modal values
* missing value + = newly recruited seedlings that were < 0.05m tall

Sites in italics were those with more than 2000 seedlings ha^{-1} in 1988 and were thought to have the potential to develop into a worthwhile crop (Grayson, 1989).

Table 2. Most abundant species of seedlings at each site in 1988 and 2002, and the heights and diameters of the most abundant species of sapling in 2002.

Size and number of trees

For each site the species with the greatest number of seedlings in 1988 or saplings in 2002 is shown in Table 2. Fifteen years after the storm all sites had saplings of at least one species. Some sites still had seedlings present, but they were found in small numbers. At many sites there was a change between the surveys in the dominant species recorded, mainly because oak or beech seedlings had often failed to develop as well as birch. In 2002 birch was the most abundant species at half of the sites. No sites were still predominantly oak, but beech and ash were the most abundant at three sites each.

Vegetation

The amount of ground vegetation present in the 67 plots recorded in 2002 varied considerably; 22% had no vegetation whilst others were dominated by a single species which had >75% cover. Overall bramble was the most frequent type of vegetation recorded and was found on more than half of the plots assessed. It was the dominant and sub-dominant vegetation in equal numbers of plots, but its cover rarely exceeded 15%. In contrast, bracken (which was the second most frequent type of vegetation) rarely occurred as a sub-dominant type and often had cover scores >75%. Other types of vegetation recorded were usually sub-dominant and had covers of <15%. Plots were occasionally dominated by shrubs such as rhododendron and bilberry.

The type of dominant vegetation present in 2002 showed some relationship with the characteristics of the soil found at each site: bracken was more frequent on plots with seasonally water-logged clay, whereas bramble or no vegetation were more frequent on well-drained soils (Table 3A). Similarly the percentage cover of the dominant species differed between soil types: plots on well-drained soils generally had lower vegetation covers than those on clays (Table 3B).

Summary of stocking

The number of plots surveyed at each site in 2002 varied between 1 and 9 (Table 4). Some plots had no regeneration of timber species, and some had none of minor species. At Abbotts Wood, Creech and Knole Park there was one plot with no regeneration of any species. There was a maximum of 4 timber and 6 minor species on any plot. The total number of all species present varied between 0 and 8 (Table 4). Across all of the plots there was wide variation in the estimated stocking density of timber species, with a range between zero and about 40,000 stems ha^{-1}. If all species were included then more than 70% of the plots were stocked at ≥1100 stems ha^{-1}.

The amount of ground flora may have influenced whether the plots were adequately stocked (i.e. ≥ 1100 saplings ha^{-1}). All plots with no vegetation had >1100 saplings ha^{-1}, and the percentage of plots stocked appeared to be lower when cover of either bramble or bracken was >15% (Table 5). However, the data for 2002 were collected long after regeneration began and it is not clear whether adequate stocking resulted from, or caused, the smaller amounts of vegetation.

Comparisons of stocking density between surveys were problematic and could really only be made for timber species, but even these were only indicative as the data available from 1988 were overall means for each site (Table 4). At Queen Elizabeth Forest and Toy's Hill, where there were

		Soil Type		
		Clay	Well-drained	Sig.
3A	Vegetation			
	Bracken	75	25	p ≤ 0.001
	Bramble	17	83	
	No vegetation*	7	93	
3B	% Cover of dominant			
	≤ 15%	19	81	p ≤ 0.01
	> 15%	57	43	

Sig. = probability that there is a difference in the percentage of plots on each soil type with either bramble or bracken, or more or less than 15% cover.
* = Data for no vegetation was not included in the statistical analysis.

Table 3. Percentage of plots with (A) different types of vegetation or (B) different amounts of cover provided by the dominant vegetation type, for sites with either clay or well-drained soils.

initially large numbers of seedlings, some of the plots surveyed in 2002 had high numbers of saplings. In contrast, sites at Alice Holt and East Hampshire initially had large numbers of seedlings of timber species in 1988, but generally few saplings of the same species in 2002. If 2000 plants ha^{-1} of timber species was used as an indicator of suitable stocking for natural regeneration (Grayson, 1989), then data in Table 4 indicate that in 1988 ten of the sites had sufficient seedlings; by 2002 this number had declined to six. Current ideology suggests that we should be more relaxed about the role of timber species in semi-natural woodland and amenity sites. Assuming that any species is an acceptable component of the regeneration, then in 2002, 14 of the sites had more than 2000 stems ha^{-1} and were adequately stocked.

Discussion

Since 1988 there has been a large change in the approach to the management of broadleaved woodland. A wide variety of native trees and shrubs are now accepted as species that can be used to restock woodlands; and acceptable stocking densities can be as low as 1100ha^{-1}. Although the initial survey reflected the contemporary interests, the emphasis on mainstream timber species made comparison of the two surveys difficult. Unfortunately it is not clear

Site		Species per plot			Stems ha^{-1}		Timber stocking ha^{-1}	
	Plots	Timber	Minor	All	Timber Spp.	All Spp.	1988	2002
Alice Holt								
Holt Pound	4	0-2	1-6	2-8	0-900	200-2900	13000	450
Abbotts Wood	3	0-1	0-2	0-3	0-900	0-1200	20400	500
Goose Green	3	0-2	1-3	1-3	0-4200	200-5500	12800	1570
East Hampshire								
Creech	5	0	0-3	0-3	0	100-800	3000	0
Queens Enclosure	2	0-1	3-4	3-4	0-200	1300-4400	38000	100
Queen Elizabeth Forest								
War Down	5	2-3	0-3	2-6	3500-11200	3600-12100	4200	6880
Head Down	3	1-2	1-3	2-4	1200-15200	3700-16000	72200	9830
Glass Brow	7	1-2	0-4	1-6	100-29400	100-29800	71200	10290
Holt Down	9	1-4	1-2	3-6	2000-40300	4800-40700	91200	19500
East Sussex								
Friston 1	1	1	0	1	12200	12200	0	12200
Friston 2	1	2	2	4	600	2500	0	600
Friston 3	1	2	3	5	300	600	0	300
Friston 4	1	0	1	1	0	300	600	0
Wych Cross	3	0	2-3	2-3	0	6400-12200	0	0
Legs Heath	3	0-1	2-4	2-4	0-100	2300-11600	1600	30
Kent								
King's Wood	5	1-2	1-3	3-5	300-1500	1500-9900	1080	1000
Toy's Hill	4	1-3	1-3	2-5	200-11000	3900-14500	16000	4050
Seven Oaks	3	0-1	2-4	2-5	0-200	6900-8100	100	70
Scotney Castle	2	0	1	1	0	400	0	0
Knole Park	2	0	0-1	0-1	0	0-12000	100	0

Stems ha^{-1} = range of values for plots at each site, seedlings were excluded.
Timber stocking ha^{-1} = mean value for stocking by timber species across all plots.

Table 4. Summary of stocking in 2002.

	% cover	Stocked	Understocked	Sig.
Bracken	≤ 15%	75	25	NS
	> 15%	44	56	
Bramble	≤ 15%	92	8	p≤0.05
	> 15%	40	60	
No vegetation*	-	100	0	

Sig. = probability of differences in the relationships between cover and stocking : NS = not significant.
* Not included in statistical analyses.

Table 5. Percentage of stocked (≥1100 ha^{-1}) and understocked plots in 2002 dominated by either bracken or bramble that was present either above or below 15% cover. Data for plots with no vegetation are also shown.

how rigorously other species minor were originally recorded. For example, birch was disregarded on some sites, whereas field maple and rowan were recorded elsewhere. In addition it is very unlikely that the survey plots were in exactly the same places at each site on both occasions. Consequently exact changes at marked positions have not been observed. Nevertheless, there appeared to have been changes between the surveys in species composition and stocking at many of the sites, but these should only be regarded as indicative.

Both surveys found that there were differences between sites in the numbers of regenerating trees present, but precise reasons for this were difficult to determine. In 1988 the number of seedlings present was not consistently related to the various site characteristics observed. The number of beech seedlings present could not be related to soil type, whereas oak appeared to show a preference for sites with surface water gleys. However, as beech and oak are masting species the presence and number of seedlings found may have been related to the production of seed during the preceding years; if there had been several years of poor or no seed production in the immediate vicinity of the assessment plot then few seedlings would have been found. The type and amount of vegetation present were the only site characteristics assessed in 2002, and it appeared that understocked plots (≤ 1100 stems ha^{-1}) had greater vegetation covers than those that were adequately stocked. The type of vegetation appeared to differ with soil; bracken was more common on clays whereas bramble occurred more frequently on well-drained soil. Similarly plots with 15% vegetation cover were more common on clays, whereas those with ≤15% cover were generally found on well-drained soils. Whilst it is unwise to draw too many conclusions from the simple observations made long after regeneration was initiated, the data do indicate that, in comparison with well-drained sites with relatively little ground vegetation, good natural regeneration after windblow can be difficult to achieve on clay sites, particularly where large amounts of bracken are likely to develop. This crude classification is consistent with detailed observations made within a single storm-damaged wood where natural regeneration was very dense on shallow, free-draining, rendzina soils but less abundant on deeper, clayey soils where bramble was abundant in patches (Mountford, 2002).

Most of the sites had, by 2002, at least partially regenerated a new crop of saplings, and some were still recruiting seedlings. However, for most sites, the dominant species of sapling present differed not only from that of the seedlings found in 1988, but also from the original crop. This change of species during natural regeneration following 1987 storm has been reported elsewhere; a typical change being the replacement of beech and oak by either birch or ash (Mountford, 2002, 2004; Mountford and Peterken, 2000; Mountford and Ball 2004; Kirby and Buckley, 1994). Failure of the original overstorey trees to regenerate satisfactorily may be due to a variety of reasons including: the regularity and amount of seed produced by birch and ash being greater than that for beech and oak; the wind dispersal of birch and ash seeds which enables them to colonise new ground, whereas the heavy seeds of beech and oak require animals for dispersal beyond their immediate canopy; and much greater predation of the large seeds of oak and beech by animals compared with seed of birch and ash. Although beech and oak are native species they may have been planted into the woodlands in which they were growing; these sites could be sub-optimal for their regeneration and more suitable for the other species which colonised the site after storm damage.

The promotion of natural regeneration as the preferred method for restocking can lead to undue optimism by managers in the expected potential of the seedlings initially present. Shelterwood systems for restocking oak and beech typically envisage the establishment of tens of thousands of seedlings per hectare, which makes the potentially useful 2000 ha^{-1} criterion suggested by Grayson (1989) seem rather low. It is perhaps not surprising using this criterion that in 2002 few of the sites remained adequately stocked with either beech or oak. There is too little information available at present to predict the survival, growth and development of tree seedlings in unmanaged areas of regeneration on different types of site, and it is difficult to give precise advice. As an example; 30-40,000 new seedlings of oak or beech may be too few for success on moisture retaining clay soils, but similar numbers of ash growing on thin soils overlaying chalk may be adequate. However, assuming that timber production is ignored, and an average of 1100 saplings ha^{-1} of any species across the site as a whole represents acceptable stocking, then 75% of the sites surveyed were successfully restocked by natural regeneration. The density of stems in some places was very high and if timber production is an aim then respacing will be necessary. The results presented provide some encouragement for managers after windblow if they are not too concerned with either the species composition or spacing of saplings across the site. They are less satisfactory for managers of oak and beech woodlands who wish to use natural regeneration to restock with the original canopy species.

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